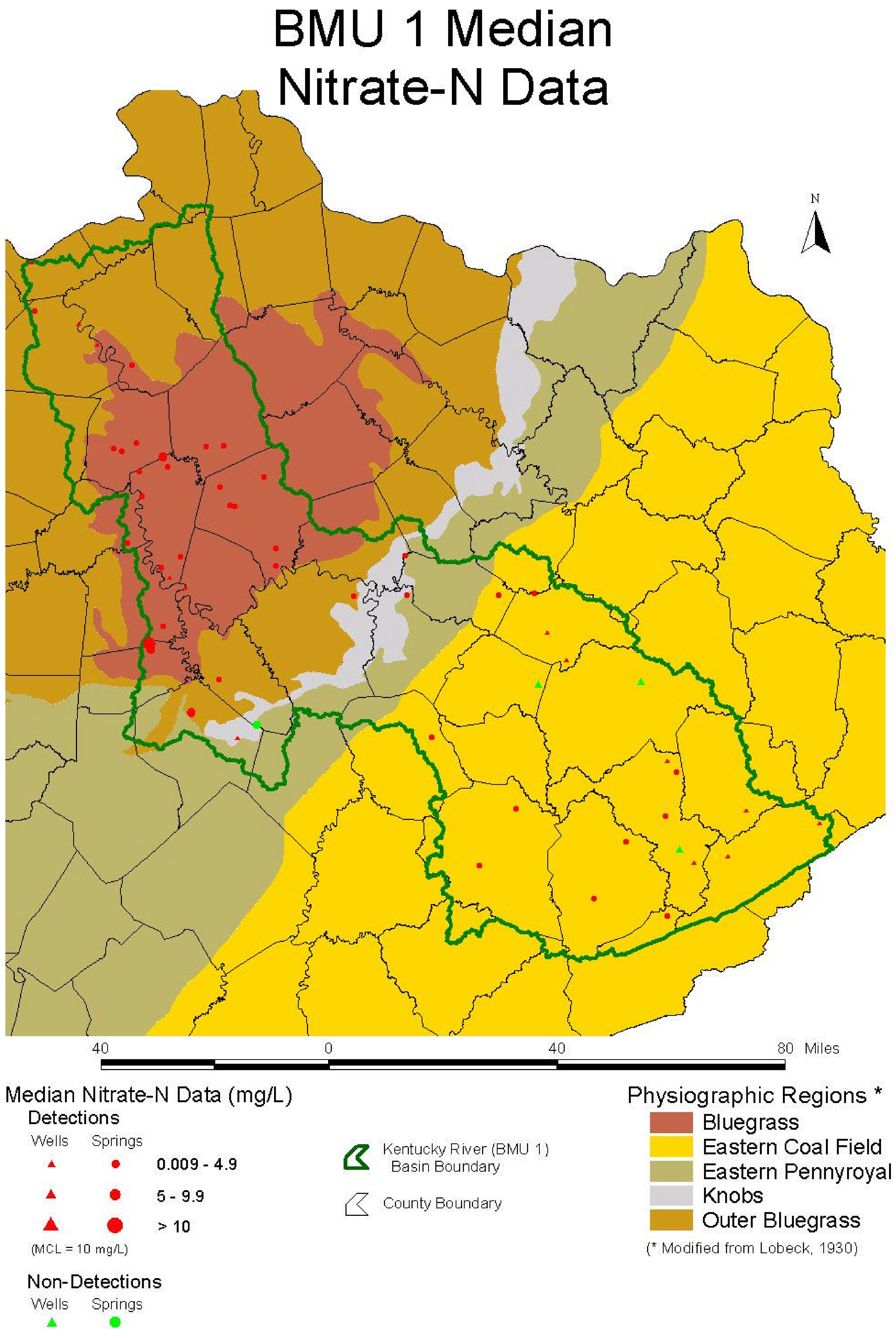

Figure 48. Nitrate-N Map

Nitrate-N values in this study were compared to the values found in other studies, as well as those from reference springs (Table 5). Based upon nitrate-N data from throughout the United States (USGS, 1984), most researchers believe that nitrate-N levels of 3.0 mg/L or lower represent background levels. However, in Kentucky some nitrate-N data suggest significantly lower levels for reference conditions. For example, a review of nitrate-N analyses from three reference springs in Kentucky (Table 5) shows a median value of 0.1805 mg/L. Carey and others (1993) found a median of 0.71 mg/L for nitrate-N in 4,859 groundwater samples collected from predominantly domestic water wells throughout the state. In their statewide study of nitrate-N, Conrad and others (1999) found that depth was a determining factor regarding the occurrence of nitrate-N in wells. Nearly 10% of shallow hand dug wells exceeded the MCL, but only about 1% of wells greater than 151 ft. were in exceedance, and median values for all wells statewide was 0.6 mg/L.

The strong positive correlation between nitrate-N concentration and percentage of agricultural land was significant (Spearman rank coefficient (r_s) = 0.78, $p < 0.0001$). Regionally, stronger positive correlations were observed in the Mississippian Plateau region ($r_s = 0.83$, $p < 0.0001$) than in the Bluegrass region ($r_s = 0.59$, $p < 0.0001$). No significant correlation was observed between nitrate-N concentration and percentage of agricultural land in the East Kentucky Coal Field or Ohio River Alluvium regions. Overall, the relationship between nitrate-N concentration and percentage of pasture land ($r_s = 0.76$, $p < 0.0001$) was stronger than that between nitrate-N concentration and percentage of row crop land use ($r_s = 0.62$, $p < 0.0001$). In the Mississippian Plateau region, correlations between nitrate-N concentration and percentage of pasture land and between nitrate-N concentration and percentage of row crop land use were equally strong ($r_s = 0.83$, $p < 0.0001$). The strong inverse relationship between nitrate-N concentration and percentage of forested land was also significant ($r_s = -0.76$, $p < 0.0001$).

These correlations do not imply that increased percentages of agricultural land cause elevated nitrate-N concentrations, rather they show that elevated nitrate-N concentrations are observed alongside increased percentages of agricultural land use. Bear in mind that 293 of 559 samples were taken at sites with less than 50% agricultural land use (90 Bluegrass, 133 East Kentucky Coal Field, 66 Mississippian Plateau, and 4 Ohio River Alluvium). Of the 266 samples taken at sites with 50% or more agricultural land use, 110 came from sites with 50% or more pasture land (102 Bluegrass, 8 Mississippian Plateau) while 156 came from sites with less than 50% pasture land (all Bluegrass).

Moderate positive correlations between nitrate-N concentration and percentage of residential land use ($r_s = 0.51$, $p < 0.0001$) and between nitrate-N concentration and percentage of commercial land use ($r_s = 0.44$, $p < 0.0001$) were also observed. Regionally, moderate positive correlations were observed in the East Kentucky Coal Field region between nitrate-N concentration and percentage of commercial land use ($r_s = 0.39$, $p < 0.0001$) and in the Mississippian Plateau region between nitrate-N concentration and percentage of residential land use ($r_s = 0.37$, $p = 0.0011$). No significant correlation was observed between nitrate-N concentration and percentage of residential or commercial land in the Bluegrass or Ohio River Alluvium regions.

Although moderate positive correlation was observed, 557 of 559 samples were taken at sites with less than 50% residential land use. Only 1 site had 50% or more residential land use; only 2 samples were taken at this site. 494 of 559 samples were taken at sites with less than 25% residential land use. Only 1 of 4 sites in the Mississippian Plateau region showed any residential land use. No sites had more than 50% commercial land use; 532 of 559 samples were taken at sites with less than 25% commercial land use. The 19 sites in the East Kentucky Coal Field region all had 10% or less commercial land use; 136 of 559 samples were taken in this region.

In conclusion, the nitrate-N medians of 3.05 mg/L for the Bluegrass and 2.525 mg/L for the Ohio River Alluvium are above statewide background levels and indicate possible nonpoint source impacts in those physiographic provinces. Elevated nitrate-N in BMU 1 may be the result of the application of nitrogen fertilizers in row crop areas, especially in the Bluegrass and the

Mississippian Plateau, and throughout the basin, other likely sources include improper management and disposal of domestic and animal waste.

Nitrite (NO_2) also occurs naturally from most of the same sources as nitrate-N. However, nitrite is an unstable ion and is usually quickly converted to nitrate in the presence of free oxygen. The MCL for nitrite-N is 1 mg/L.

Nitrite-N was found in 304 of 546 (55.7%) of the samples included in this study (Table 17). The median for BMU 1 was 0.0045 mg/L, and the maximum was 0.134 mg/L, which occurred in the Bluegrass (Table 18). Nitrite-N values occur within narrow ranges plotted against physiographic regions and land use, but some outliers do occur (Figures 49 and 50). Map distribution is shown in Figure 51.

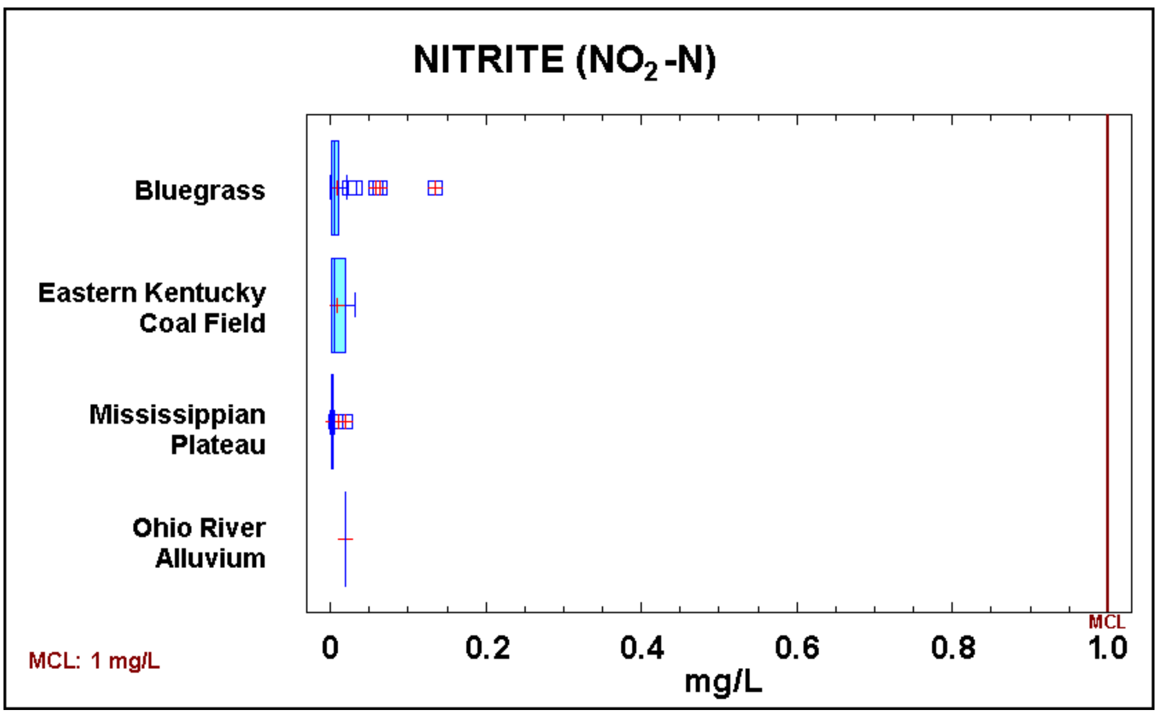

Figure 49. Boxplot of Nitrite-N and Physiographic Regions

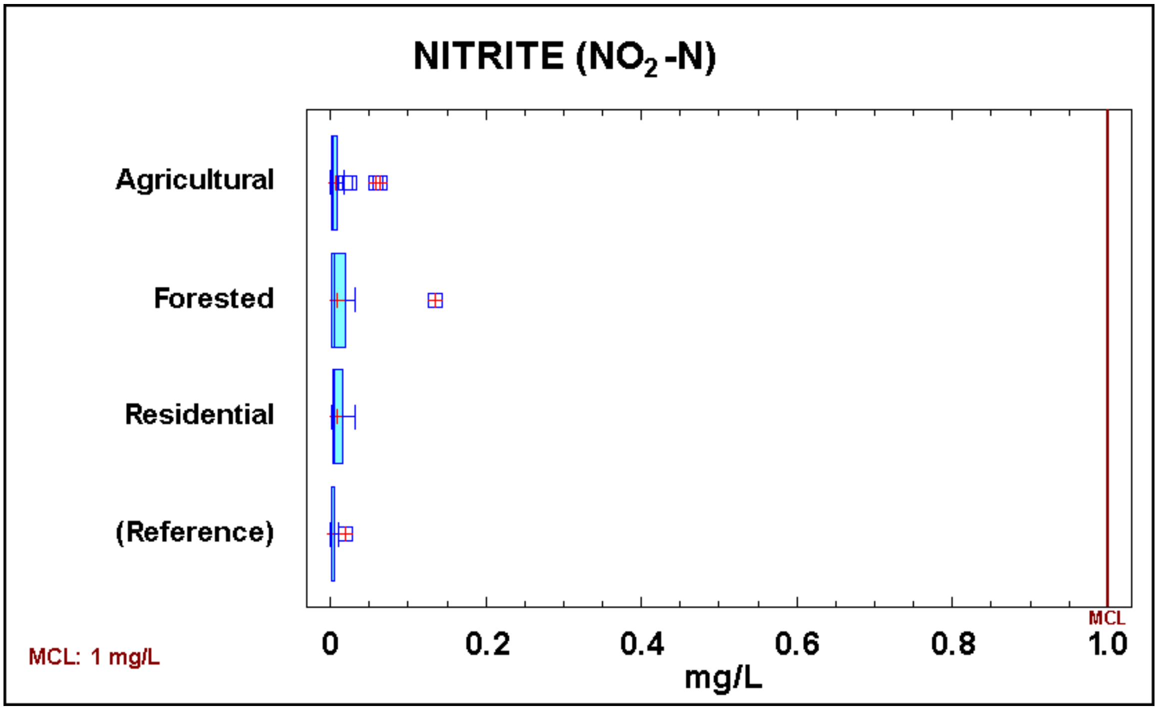

Figure 50. Boxplot of Nitrite-N and Land Use

In the environment, nitrite generally converts rapidly to nitrate through oxidation. This study supports that and nitrite-N was not found to be a significant nonpoint source pollutant in BMU 1, although it may contribute to high levels of nitrate-N.

Ammonia-N (NH_3) occurs naturally in the environment, primarily from the decay of plants and animal waste. The principal source of anthropogenic ammonia-N in groundwater is from ammonia-N based fertilizers. No drinking water standards exist for ammonia-N; however, the proposed DEP limit for groundwater is 0.110 mg/L.

In 560 samples included in this study, ammonia-N was detected in 107, or 19.1% (Table 17). The maximum value of 22.5 mg/L found in the Bluegrass and the median for BMU 1 was 0.02 mg/L (Table 18). Ammonia-N occurs in a narrow range in all physiographic provinces (Figure 52), but outliers are common in the Bluegrass and the Eastern Coal Field. In the former, this may reflect the application of ammonia-N based fertilizers on row crops; in the latter, where

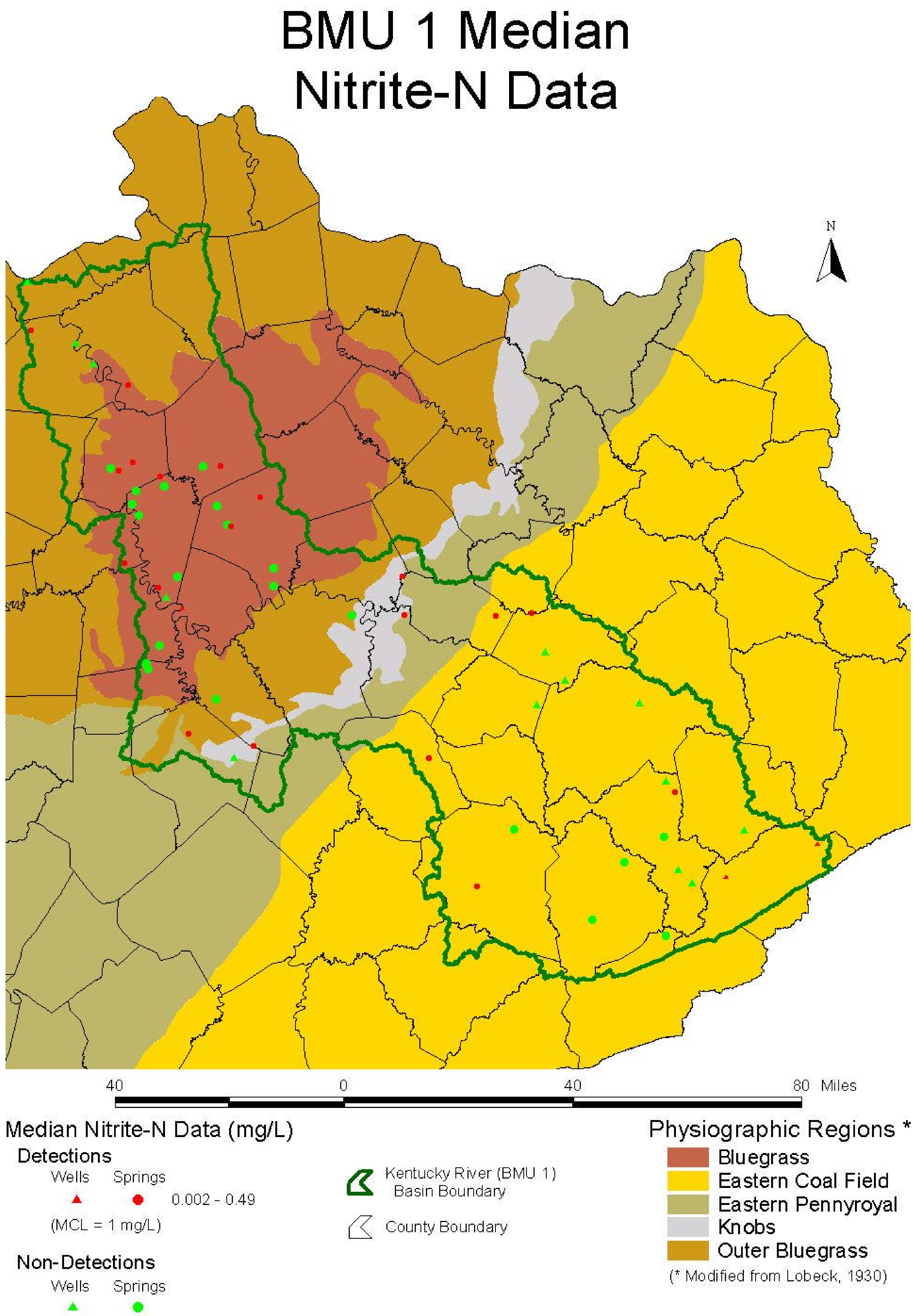

Figure 51. Nitrite-N Map

row crops are uncommon, this may be the result of the improper disposal of household septic waste. Figure 53 shows elevated values in agricultural areas, which is expected; however, an unexpected result was that elevated values were also found in forested areas. Reference springs, which drain forested areas, had a median value of 0.02 mg/L, suggesting that values above this indicate nonpoint source impacts. The source of elevated ammonia-N from groundwater in forested areas is therefore difficult to interpret. The MCL was exceeded at seven sites in the Bluegrass and ten in the Eastern Coal Field (Figure 54).

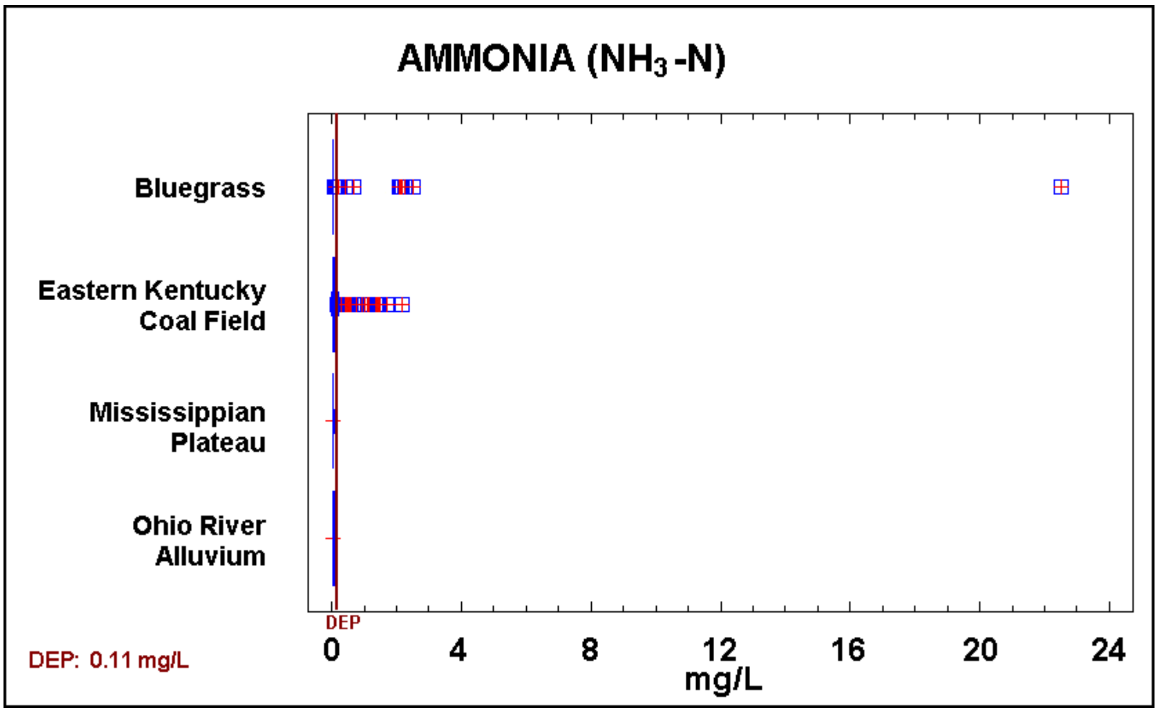

Figure 52. Boxplot of Ammonia-N and Physiographic Regions

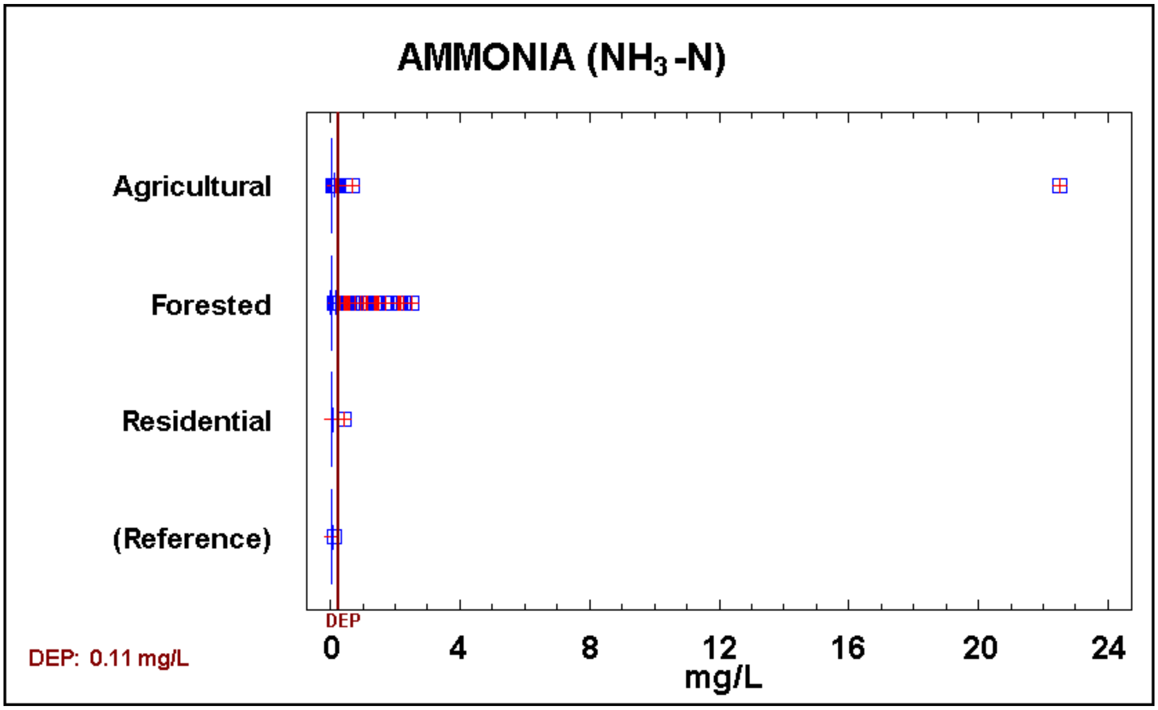

Figure 53. Boxplot of Ammonia-N and Land Use

Two forms of phosphorus are discussed in this report: orthophosphate-P and total phosphorus. Orthophosphate-P (PO_4-P), or "ortho-p," is the final product of the dissociation of phosphoric acid, H_3PO_4. It occurs naturally in the environment most often as the result of the oxidation of organic forms of phosphorus; it is found in animal waste and in detergents. Orthophosphate-P is the most abundant form of phosphorus, usually accounting for about 90% of the available phosphorus. Phosphorus contributes to the eutrophication of surface water, particularly lakes, commonly known as "algal blooms".

The most common phosphorus mineral is apatite [$Ca_5(PO_4)_3(OH,F,Cl)$], which is found in the phosphatic limestones in the Bluegrass. Neither orthophosphate-P nor total phosphorus has a drinking water standard. Orthophosphate-P data are compared to the Texas surface water quality standard of 0.04 mg/L and total phosphorus data to the surface water limit of 0.1 mg/L recommended by the USGS.

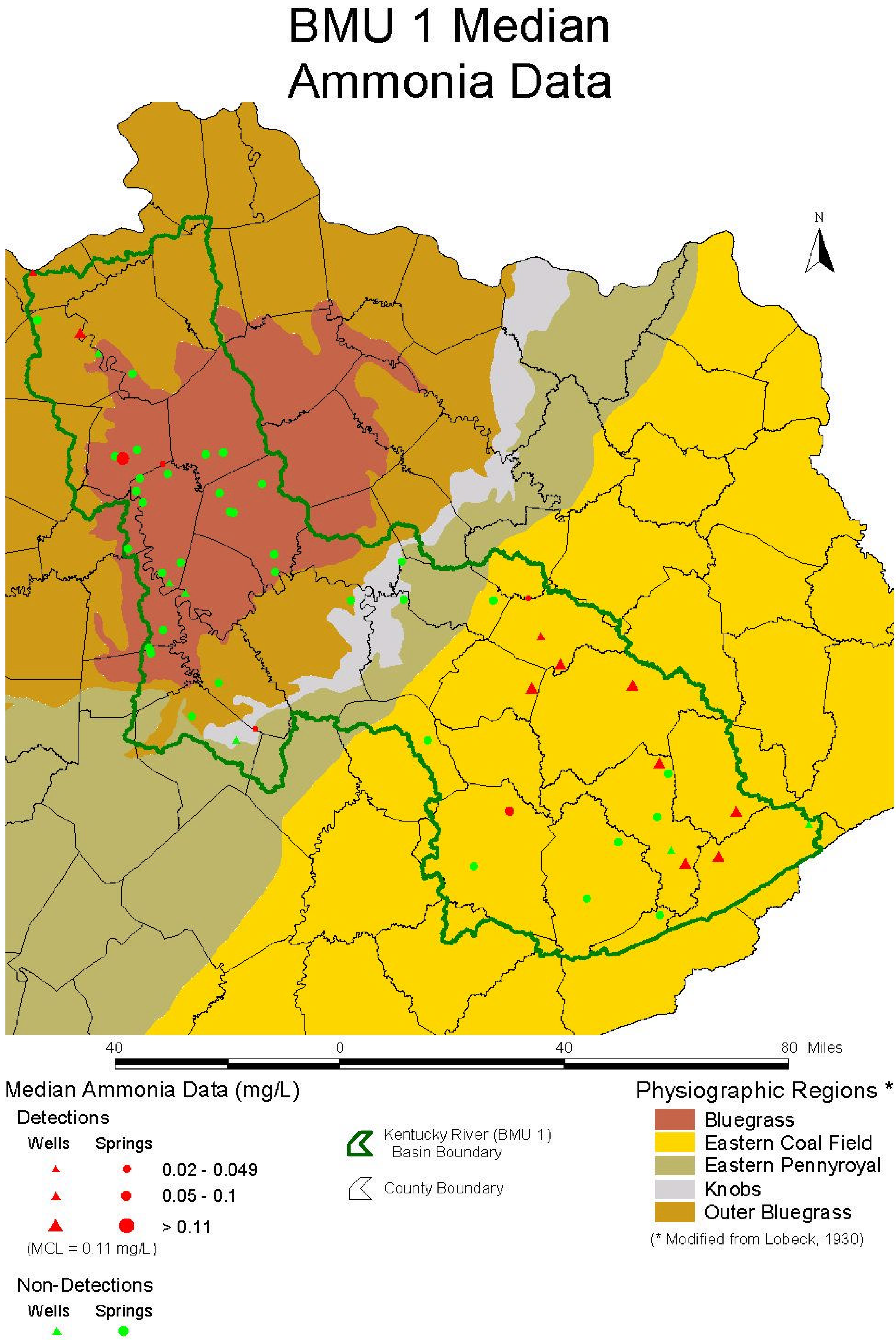

Figure 54. Ammonia-N Map

In natural systems relatively unimpacted from anthropogenic sources, orthophosphate-P occurs at very low levels. For example, reference reach springs typically were either non-detect for orthophosphate-P, or had values in the range of 0.002 – 0.004 mg/L. Although some more sensitive laboratory methods were used in this study, the most common MDL was 0.059 mg/L, which is above the surface water quality standard of 0.04 mg/L used for comparison in this study.

Orthophosphate-P was analyzed in 549 samples and found in 417, or 76.0% (Table 17). The median for BMU 1 was 0.06 mg/L. In general, the Bluegrass had the highest orthophosphate-P with a median of 0.1805 mg/L (Table 18), which may result in part from the underlying geology, but which also may reflect agricultural and residential land use (Figure 55). Nonpoint source impacts of orthophosphate-P on groundwater are difficult to interpret because this compound is both naturally occurring and can be introduced through anthropogenic activity. Map distribution of orthophosphate-P in BMU 1 is shown in Figure 56.

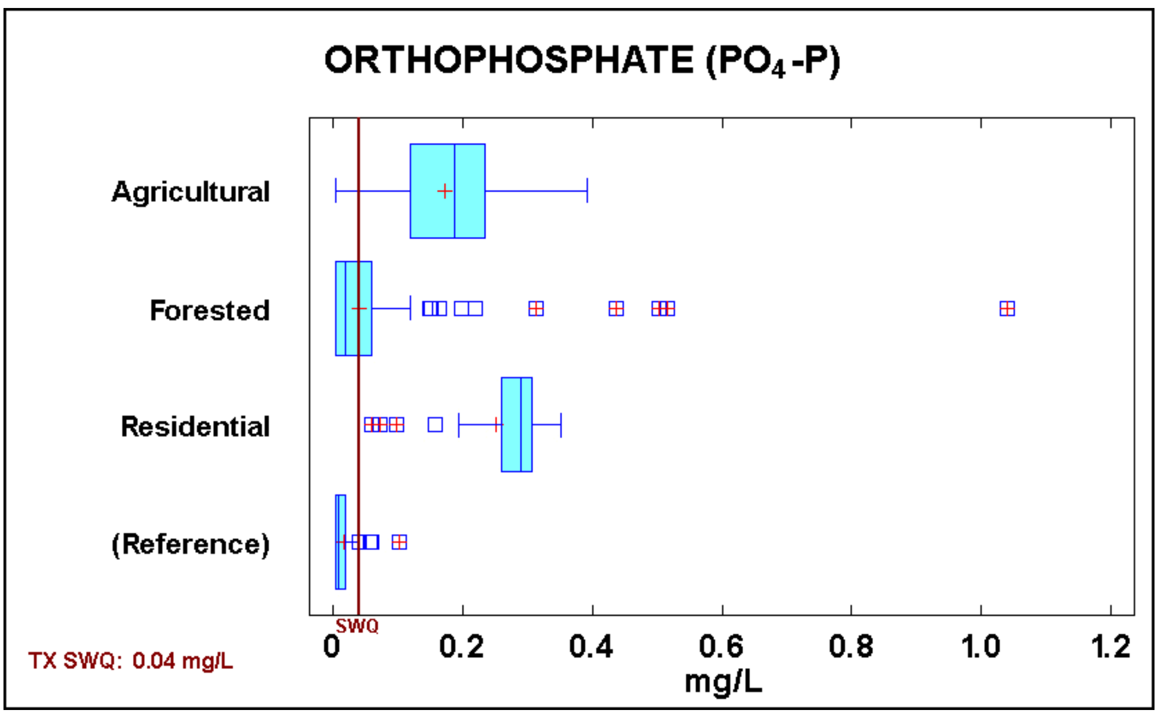

Figure 55. Boxplot of Orthophosphate-P and Land Use

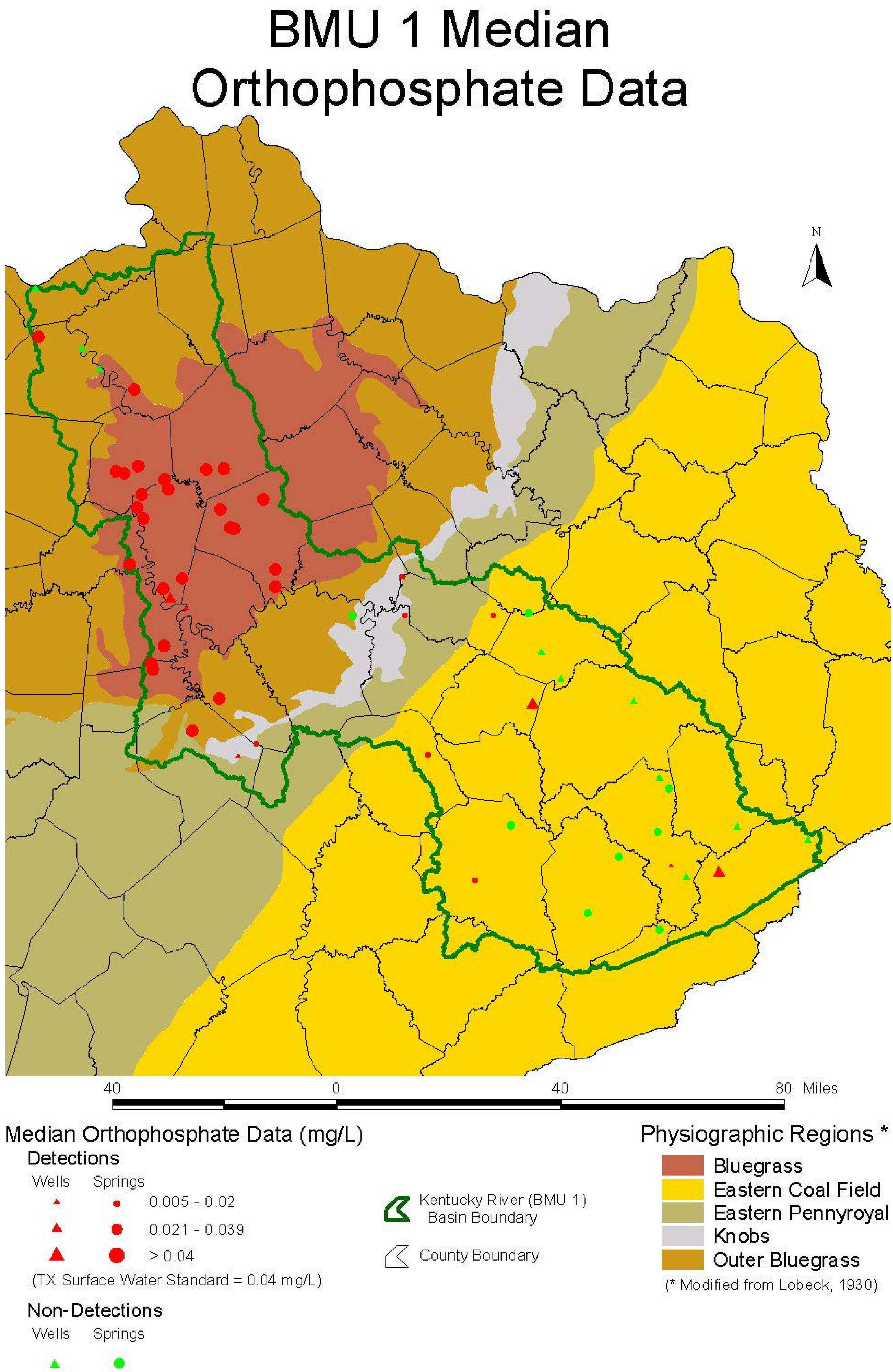

Figure 56. Orthophosphate-P Map